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Abstract

Space Station Freedom is designed to be an Earth-orbiting multidiscipline research and development (R&D) facility capable of evolution to accommodate a variety of potential uses. One evolution scenario is growth to an enhanced R&D facility. In support of the Space Station Freedom Program Preliminary Design Review, the NASA Langley Research Center Space Station Office is analyzing growth requirements and evaluating configurations for this R&D utilization. This paper presents a summary of this analysis including time-phased growth plans, R&D growth issues and configurations, and recommendations for the program baseline design which will facilitate evolutionary R&D growth.

SPACE STATION TRANSPORTATION NODE CONCEPTS & ANALYSIS

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Abstract

Accommodation of the new Human Exploration Initiative being developed by NASA requires Space Station Freedom to serve three major roles: first, as a facility for precursory technology development and life sciences research for both transportation systems and lunar/Mars outpost systems; second, as a transportation node capable of processing both lunar- and Mars-class transportation vehicles and their accompanying payloads. This processing includes all required initial vehicle assembly, mating, servicing, refurbishment, and repair. In addition, some amount of mission propellant may be stored and transferred on Freedom. Third, Freedom provides an ideal testbed for developing operational techniques that are applicable to the Human Exploration Initiative missions.

The work performed under this task and presented in this briefing serves to define and prepare Space Station Freedom evolution in keeping with the mission needs stated above by

1. Defining Freedom transportation node evolution configurations consistent with user requirements and program constraints

2. Defining and incorporating baseline design accommodations (hardware "scars" and software "hooks") to satisfy evolution requirements

3. Identifying advanced technology that will enhance Freedom's capabilities and enables its evolution

N94-72180

SERVICING CAPABILITY FOR THE EVOLUTIONARY SPACE STATION

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Abstract

As NASA prepares to establish a permanently manned presence in space, a unique opportunity will exist, namely the ability to service user systems to extend their useful lifetime, thus providing a significant enhancement in the production of scientific data. Since the beginning of the Space Station Freedom (SSF) program the concept of on-orbit servicing of user hardware has been an integral part of the program implementation.

The user servicing system architecture has been divided into a baseline and a growth phase. The baseline system consists of the following hardware elements that will support user servicing - flight telerobotic servicer, crew and equipment translation aid, crew intravehicular and extravehicular servicing support, logistics supply system, mobile servicing center, and the special purpose dextrous manipulator. The growth phase incorporates a customer servicing facility (CSF), a station-based orbital maneuvering vehicle and an orbital spacecraft consumables resupply system.

The requirements for user servicing were derived from the necessity to service attached payloads, free flyers and coorbiting platforms. These requirements include: orbital replacement units (ORU) and instrument changeout, National Space Transportation System cargo bay loading and unloading, contamination control and monitoring, thermal protection, payload berthing, storage, access to SSF distributed systems, functional checkout, and fluid replenishment.

The baseline user servicing capabilities accommodate ORU and instrument changeout. However, this service is limited to attached payloads, either in situ or at a locally adjacent site. The growth phase satisfies all identified user servicing requirements by expanding servicing capabilities to include complex servicing tasks for attached payloads, free-flyers and coorbiting platforms at a dedicated, protected servicing site.

To provide a smooth evolution of user servicing the SSF interfaces that are necessary to accommodate the growth phase have been identified. The interface requirements on SSF have been greatly simplified by accommodating the growth servicing support elements within the CSF. This results in a single SSF interface: SSF to the CSF.

From these interface requirements the necessary "hook and scar" requirements for the baseline SSF have been identified. Hooks in the SSF Operations Management System are necessary for all the CSF subsystems while scars to the SSF distributed systems are necessary for the CSF structural & mechanical, electrical power, thermal control, fluid management, data management, and communication & tracking systems.

The requirements and capabilities to support the servicing of user hardware have been evaluated for both the SSF baseline and growth phases. At assembly complete only limited servicing for attached payloads can be accommodated. However, the servicing capabilities are greatly enhanced during the growth phase of the SSF through the addition of the growth user servicing elements. These enhanced capabilities satisfy all identified requirements. Evaluation of proposed SSF evolutionary configurations indicates that there is no impact to the servicing system architecture and no major impact to the implementation of this architecture.

N94-72181

EVOLUTIONARY SPACE STATION FLUIDS MANAGEMENT

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54-18
P-1

Abstract

The demand for and management issues associated with fluids usage at the evolutionary Space Station are examined. A variety of fluids such as N_2, H_e, methane and rare gases for research and development activities as well as massive quantities of cryogenic propellants for geosynchronous orbit and planetary exploration missions will need to be accommodated at the Space Station. A data base of fluid types, quantities, and projected usage schedules suggested, and potential accommodation concepts defined. Impacts to the Space Station operational configuration and necessary "hooks and scars" to be included in the baseline design are addressed. Also presented is an operational scenario of the delivery of a cryogenic propellant tank set to the Space Station, attachment to the Space Station, and propellant transfer to and launch of a space transfer vehicle (STV). Results indicate that the cryogenic propellant requirements of STV and lunar missions may be met by tank sets attached to the Space Station, but those of Mars missions would require off-station methods.

SPACE STATION LOGISTICS SYSTEM EVOLUTION

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Abstract

This task investigates logistics requirements and logistics system concepts for the evolutionary Space Station. Requirements for the basic station, crew, user equipment, and free-flying platforms, as requirements for manned exploration initiative elements and crews while at the Space Station. Data is provided which assesses the ability of the Space Station Freedom logistics carriers to accommodate the logistics loads per year. Also, advanced carrier concepts are defined and assessed against the logistics requirements. The implications on Earth-to-orbit vehicles of accommodating the logistics requirements, using various types of carriers, are assessed on a year by year basis.

N94-72183

SPACE TRANSFER VEHICLE ACCOMMODATIONS AT TRANSPORTATION NODES

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Abstract

This task identifies requirements for accommodation of space transfer vehicles (STVs) at orbital transportation nodes. Requirements are based on mission models which include high energy missions and human exploration initiatives. Study data includes results of trade studies evaluating STV accommodations concepts at Space Station nodes and at alternative free-flying nodes. Data and scars on the Phase One Space Station Freedom to allow growth to the accommodation concepts are identified.

A RADIOLOGICAL ASSESSMENT OF SPACE NUCLEAR POWER OPERATIONS NEAR SPACE STATION FREEDOM

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Abstract

In order to accomplish NASA's more ambitious exploration goals, nuclear reactors may be used in the vicinity of Space Station Freedom (SSF) either as power sources for coorbiting platforms or as part of the propulsion system for departing and returning personnel or cargo vehicles. This study identifies ranges of operational parameters, such as parking distances and reactor cooldown times, which would reasonably guarantee that doses to the SSF crew from all radiation sources would be below guidelines recently recommended by the National Council of Radiation Protection and Measurements. The specific scenarios considered include:

1. the launch and return of a nuclear electric propulsion vehicle,
2. the launch and return of a nuclear thermal rocket vehicle,
3. the operation of an SP-100 class reactor on a coorbiting platform,
4. the activation of materials near operating reactors,
5. the storage and handling of radioisotope thermal generator units, and
6. the storage and handling of fresh and previously operated reactors.

Portable reactor shield concepts were examined for relaxing the operational constraints imposed by unshielded (for human proximity operations) reactors and that might also be used to provide additional SSF crew protection from natural background radiation.

N94-72185

PLATFORM EVOLUTION STUDIES

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P-1

Abstract

The polar orbiting platform (POP), being developed by the Work Package 3 (WP3) Project at the Goddard Space Flight Center, will play a key role in the NASA Leadership Initiative, Mission to Planet Earth (MPE). It becomes, with the addition of payloads, an Earth observation satellite observatory.

Mission to Planet Earth also has geostationary platforms (GEOP) as part of its global observational system. A study was begun in March 1988 to assess the applicability of the POP orbital replacement units (ORUs) for a geostationary Earth observing mission. Two test cases, representative of MPE payloads, were studied. Case A was used to emphasize the GEOP configuration and design; it used a Titan/Centaur to achieve orbit. Case B, considered to be much further in the future, included some assembly at the Space Station Freedom manned base and use of an orbital transfer vehicle to achieve orbit; requirements on the manned base to support such a mission were emphasized.

The study found the POP systems more than adequate to meet GEOP requirements. Two types of changes were required for the POP ORUs:

1. modification to use only one surface for heat rejection; for the battery ORU, this meant 'opening up' the ORU to retain the radiator area with a corresponding decrease in depth, and

2. deletion of equipment not needed.

The Case A configuration was shown to be within the planned capability of the Titan IV/Centaur. Assembly requirements were included for the Case B configuration, which is driven by the large microwave antennas of two of the payloads. The final review was April 19, 1989.

N94-72186

AUTONOMOUS POWER MANAGEMENT AND DISTRIBUTION

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Abstract

The goal of the Autonomous Power System program is to develop and apply intelligent problem solving and control to the Space Station Freedom's electric power testbed being developed at NASA's Lewis Research Center. Objectives are to establish artificial intelligence technology paths, craft knowledge-based tools and products for power systems, and integrate knowledge-based and conventional controllers.

This program represents a joint effort between the Space Station and Office of Aeronautics and Space Technology to develop and demonstrate space electric power automation technology capable of:

1. detection and classification of system operating status,

2. diagnosis of failure causes, and

3. cooperative problem solving for power scheduling and failure recovery.

Program details, status, and plans will be presented.

SPACE STATION MODULE POWER MANAGEMENT AND DISTRIBUTION (PMAD) SYSTEM

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Abstract

This project consists of several tasks which are unified toward experimentally demonstrating the operation of a highly autonomous, user-supportive power management and distribution system for Space Station Freedom (SSF) habitation/laboratory modules. This goal will be extended to a demonstration of autonomous, cooperative power system operation for the whole SSF power system through a joint effort with NASA's Lewis Research Center, using their Autonomous Power System.

Short term goals for the space station module power management and distribution include having an operational breadboard reflecting current plans for SSF, improving performance of the system communications, and improving the organization and mutability of the artificial intelligence (AI) systems. In the middle term, intermediate levels of autonomy will be added, user interfaces will be modified, and enhanced modeling capabilities will be integrated in the system. Long term goals involve conversion of all software into Ada, vigorous verification and validation efforts and, finally, seeing an impact of this research on the operation of SSF.

Conversion of the system to a DC Star configuration is now in progress, and should be completed by the end of October, 1989. This configuration reflects the latest SSF module architecture. Hardware is now being procured which will improve system communications significantly. The Knowledge-Based Management System (KBMS) is initially developed and the rules from FRAMES have been implemented in the KBMS. Rules in the other two AI systems are also being grouped modularly, making them more tractable, and easier to eventually move into the KBMS. Adding an intermediate level of autonomy will require development of a planning utility, which will also be built using the KBMS. These changes will require having the user interface for the whole system available from one interface. An Enhanced Model will be developed, which will allow exercise of the system through the interface without requiring all of the power hardware to be operational. The functionality of the AI systems will continue to be advanced, including incipient failure detection. Ada conversion will begin with the lowest level processor (LLP) code. Then selected pieces of the higher level functionality will be recoded in Ada and, where possible, moved to the LLP level. Validation and verification will be done on the Ada code, and will complete sometime after completion of the Ada conversion.

N94-72188

THE ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM (ECLSS) ADVANCED AUTOMATION PROJECT

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Abstract

The objective of the environmental control and life support system (ECLSS) Advanced Automation Project is to influence the design of the initial and evolutionary Space Station Freedom Program (SSFP) ECLSS toward a man-made closed environment in which minimal flight and ground manpower is needed. Another objective includes capturing ECLSS design and development knowledge for future missions.

Our approach has been to

1. analyze the SSFP ECLSS,

2. envision as our goal a fully automated evolutionary environmental control System - an augmentation of the baseline, and

3. document the advanced software systems, hooks, and scars which will be necessary to achieve this goal.

From this analysis, prototype software is being developed, and will be tested using air and water recovery simulations and hardware subsystems.

In addition, the advanced software is being designed, developed, and tested using an automation software management plan and lifecycle tools. Automated knowledge acquisition, engineering, verification and testing tools are being used to develop the software. In this way, we can capture ECLSS development knowledge for future use, develop more robust and complex software, provide feedback to the knowledge based system tool community, and ensure proper visibility of our efforts.

"PI-IN-A-BOX": AN EXPERT SYSTEM TO ADVISE ASTRONAUTS DURING EXPERIMENTS

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Abstract

Perhaps the scarcest resource for manned flight experiments - on Spacelab or on Space Station Freedom - will continue to be crew time. To maximize the efficiency of the crew, and to make use of their abilities to work as scientist collaborators as well as equipment operators, normally requires more training in a wide variety of disciplines than is practical. The successful application of on-board expert systems, as envisioned by the "Principal Investigator (PI)-in-a-Box" program, should alleviate the training bottleneck and provide the astronaut with the guidance and coaching needed to permit him or her to operate an experiment according to the desires and knowledge of the PI, despite changes in conditions. In addition to the functions of providing expert advise concerning scheduling and repair, the program should bring the astronaut into the scientific evaluation phase of an experiment by sharing with him the guidance and observations regarding the relevance and importance of data as it is being generated. Initial reaction from the astronaut community has been positive.

N94-72190

REACTION CONTROL SYSTEM/REMOTE MANIPULATOR SYSTEM AUTOMATION

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Abstract

The objective of this project is to evaluate the capability of the Procedural Reasoning System (PRS) in a typical real-time space shuttle application and to assess its potential for use in the Space Station Freedom. PRS, developed by SRI International, is a result of research in automating the monitoring and control of spacecraft systems. The particular application selected for the present work is the automation of malfunction handling procedures for the Shuttle Remote Manipulator System (SRMS). The SRMS malfunction procedures will be encoded within the PRS framework, a crew interface appropriate to the RMS application will be developed, and the real-time data interface software developed. The resulting PRS will then be integrated with the high-fidelity Onorbit Simulation of the NASA Johnson Space Center's Systems Engineering Simulator, and tests under various SRMS fault scenarios will be conducted.

N94-72191

TEXSYS

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Abstract

The Systems Autonomy Demonstration Project has recently completed a major test and evaluation of TEXSYS, a knowledge-based system (KBS) which demonstrates real-time control and FDIR for the Space Station Freedom thermal control system test-bed. TEXSYS is the largest KBS ever developed by NASA and offers a unique opportunity for the study of technical issues associated with the use of advanced KBS concepts including: model-based reasoning and diagnosis, quantitative and qualitative reasoning, integrated use of model-based and rule-based representations, temporal reasoning, and scale-up performance issues. TEXSYS represents a major achievement in advanced automation that has the potential to significantly influence Space Station Freedom's design for the thermal control system. An overview of the Systems Autonomy Demonstration Project, the thermal control system test-bed, the TEXSYS architecture, preliminary test results, and thermal domain expert feedback are presented.

SUMMARY OF ASTRONAUT INPUTS CONCERNING AUTOMATION

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Abstract

An assessment of the potential for increased productivity on Space Station Freedom through advanced automation and robotics was recently completed. Sponsored by the Office of Space Station, the study involved reviews of on-orbit operations experience documentation, interviews with 23 current and former astronauts/payload specialists as well as other NASA and contractor personnel, and a survey of 32 astronauts and payload specialists. Assessed areas of related on-orbit experience included Skylab, Space Shuttle, Spacelab, and the Soviet space program, as well as the U.S. nuclear submarine program and Antarctic research stations analogs. The survey questionnaire asked the respondents to rate the desirability of advanced automation, EVA robotics, and IVA robotics. They were also asked to rate safety impacts of automated fault diagnosis, isolation, and recovery (FDIR), automated exception reporting and alarm filtering, and an EVA retriever. The respondents were also asked to evaluate 26 specific applications of advanced automation and robotics related to perceived impact on productivity.

N94-72193

ASSURING DATA TRANSPARENCY THROUGH DESIGN METHODOLOGIES

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S/6-12
10436
P-1

Abstract

This paper addresses the role of design methodologies and practices in the assurance of technology transparency. The development of several major subsystems on large, long lifecycle government programs was analyzed to glean those characteristics in the design, development, test and evaluation that precluded or enabled the insertion of new technology. The programs examined were Minuteman, DSP, B1-B, and space shuttle. All these were long lifecycle, technology-intensive programs. The design methodologies (or lack thereof) and design practices for each were analyzed in terms of the success or failure in incorporating evolving technology. Common elements contributing to the success or failure were extracted and compared to current methodologies being proposed by the Department of Defense and NASA. The relevance of these practices to the design and deployment of Space Station Freedom were evaluated. In particular, appropriate methodologies now being used on the Core development contract were examined.

N94-72194

SPACE STATION FREEDOM EXTRAVEHICULAR ACTIVITY SYSTEMS EVOLUTION STUDY

Mike Rouen
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Abstract

Evaluation of Space Station Freedom (SSF) support of manned exploration is in progress to identify SSF extravehicular activity (EVA) system evolution requirements and capabilities. The output from these studies will provide data to support the preliminary design process to ensure that Space Station EVA system requirements for future missions (including the transportation node) are adequately considered and reflected in the baseline design. The study considers SSF support of future missions and the EVA system baseline to determine adequacy of EVA requirements and capabilities, and to identify additional requirements, capabilities, and necessary technology upgrades.

The EVA demands levied by formal requirements and indicated by evolutionary mission scenarios are high for the out-years of Space Station Freedom. An EVA system designed to meet the baseline requirements can easily evolve to meet evolution demands with few exceptions. Results to date indicate that upgrades or modifications to the EVA system may be necessary to meet the full range of EVA thermal environments associated with the transportation node. Work continues to quantify the EVA capability in this regard. Evolution mission scenarios with EVA in and around unshielded nuclear propulsion engines are inconsistent with anthropomorphic EVA capabilities.

N94-72195

DATA MANAGEMENT SYSTEM EVOLUTION STUDY

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Abstract

Hardware and software products, and technologies that are available for implementation in the early Space Station Data Management system (DMS) design are expected to have limited capabilities in such areas as system performance, capacity, and throughput. With the anticipated growth in operations and payload user requirements during the Space Station's operational phase, a knowledge base of technological advancements and their possible incorporation into the DMS design will be maintained.

This paper will address system growth and technology insertion issues for DMS design and development.

SPACE STATION THERMAL CONTROL SYSTEM EVOLUTION

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Abstract

The thermal control system (TCS) for the Space Station assembly complete configuration includes a two-phase central thermal bus with a supplemental body mounted radiator system. Evolution of the Space Station from a heat rejection capacity of 75 kW to 300 kW will require scars to expand the thermal fluid distribution network, equipment replacement to enable greater thermal transport capacity, and enlargement of the heat rejection subsystem for increased heat rejection. The TCS requirements for assembly complete and growth are presented, along with a review of the basic structure of the active and passive thermal control systems which include provisions for growth.

EVOLUTIONARY SPACE STATION GUIDANCE NAVIGATION AND CONTROL (GN&C) STUDY

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Abstract

The Guidance, Navigation and Control (GN&C)techniques and equipment to support evolutionary Space Station concepts were analyzed. Simulations of the evolutionary Space Station configurations and operational concepts were conducted to analyze the attitude control, reboost, and traffic management accommodation requirements. A summary of the mission concepts, Space Station configurations, simulation results, and the impacts on the baseline GN&C systems are presented.

COMMUNICATION AND TRACKING SYSTEM EVOLUTION STUDY

William Culpepper
NASA Johnson Space Center

Abstract

The communications & tracking (C&T) techniques and equipment to support evolutionary Space Station concepts are being analyzed. Evolutionary Space Station configurations and operational concepts were used in the analysis to derive the results to date. A description of the C&T system based on future capability needs is presented. Included are the "hooks and scars" currently identified to support the future growth. Technology transparency and impact of growth on other systems are also addressed.

STRUCTURAL DYNAMIC AND CONTROL CONSIDERATIONS FOR SPACE STATION TRANSPORTATION NODE CONCEPTS

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Abstract

This paper discusses the results of two studies which investigated the expected low frequency dynamic characteristics of conceptual Mars and lunar transportation nodes. Both concepts are based on evolution of the assembly-complete Space Station Freedom configuration by the addition of keels, booms and modules. Finite-element models of the concepts were developed and a set of undamped modes and frequencies was computed below 2 Hz for each concept. The modes were used as basis vectors for modal analyses describing the dynamic response of the structures to typical reboost maneuvers. The reboost maneuvers had fairly complex loading characteristics since the reaction control system (RCS) jets used for the maneuvers were off-modulated to control pitch and yaw attitude,. Interaction of the dynamic response of the structure with the closed-loop attitude control system is investigated for both concepts. The elastic response in the solar dynamic region is investigated to evaluate the severity of the dynamic environment, since the solar dynamic systems have stringent sun-pointing requirements which must be maintained during the reboost maneuver.

N94- 72200

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM EVOLUTION

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Abstract

Space Station growth scenarios were reviewed and environmental control and life support system (ECLSS) growth requirements and ECLSS-driven constraints were derived. A broad range of advanced ECLSS technologies were evaluated for their potential of being developed for flight use. Based on these evaluations the "hooks and scars" needed to accommodate subsystems based on the technologies were defined with particular attention to the fluid and electrical interface requirements.

REAL-TIME DATA SYSTEM: INCORPORATING NEW TECHNOLOGY IN MISSION CRITICAL ENVIRONMENTS

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Abstract

If the Space Station Freedom is to remain viable over its 30-year life span, it must be able to incorporate new information systems technologies. These technologies are necessary to enhance mission effectiveness and to enable new NASA missions, such as supporting the Lunar-Mars Initiative. Hi-definition television (HDTV), neural nets, model-based reasoning, advanced languages, CPU designs, and computer networking standards are areas which have been forecasted to make major strides in the next 30 years. A major challenge to NASA is to bring these technologies online without compromising mission safety. In past programs, NASA managers have been understandably reluctant to rely on new technologies for mission critical activities until they are proven in noncritical areas. NASA must develop strategies to allow inflight confidence building and migration of technologies into the trusted tool base.

NASA has successfully met this challenge and developed a winning strategy in the Space Shuttle Mission Control Center. This facility, which is clearly among NASA's most critical, is based on 1970's mainframe architecture. Changes to the mainframe are very expensive due to the extensive testing required to prove that changes do not have unanticipated impact on critical processes. Systematic improvement efforts in this facility have been delayed due to this "risk to change".

In the Real-Time Data System (RTDS) we have introduced a network of engineering computer workstations which run in parallel to the mainframe system. These workstations are located next to flight controller operating positions in Mission Control and, in some cases, the display units are mounted in the traditional mainframe consoles.

This system incorporates several major improvements over the mainframe consoles, including automated fault detection by real-time expert systems and color graphic animated schematics of subsystems driven by real-time telemetry. The workstations have the capability of recording telemetry data and providing "instant replay" for flight controllers. RTDS also provides unique graphics animated by real-time telemetry such as workstation emulation of the Shuttle's flight instruments and display of the remote manipulator system (RMS) position. These systems have been used successfully as prime operational tools since STS-26, and have supported seven Shuttle missions.

Elements of the RTDS strategy that have made it successful include:

1. Isolation of new technology efforts from critical systems
2. Connectivity to real-time data
3. Ability to generate results in real-time
4. Physical proximity to users in an operational environment
5. "Firewalling" the system to isolate the effects of change and allow rapid prototyping
6. Electronic access to spacecraft configuration design information

N94- 72202

TRANSITION FLIGHT CONTROL ROOM AUTOMATION

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P-1

Abstract

The Workstation Prototype Laboratory is currently working on a number of projects which can have a direct impact on ground operations automation. These projects include:

- The Fuel Cell Monitoring System (FCMS), which will monitor and detect problems with the fuel cells on the Shuttle. FCMS will use a combination of rules (forward/backward) and multithreaded procedures, which run concurrently with the rules, to implement the malfunction algorithms of the EGIL flight controllers. The combination of rule-based reasoning and procedural reasoning allows us to more easily map the malfunction algorithms into a real-time system implementation.

- A graphical computation language (AGCOMPL), is an experimental prototype to determine the benefits and drawbacks of using a graphical language to design computations (algorithms) to work on Shuttle or Space Station telemetry and trajectory data.

- The design of a system which will allow a model of an electrical system, including telemetry sensors, to be configured on the screen graphically using previously defined electrical icons. This electrical model would then be used to generate rules and procedures for detecting malfunctions in the electrical components of the model.

- A generic message management (GMM) system. GMM is being designed for real-time applications as a message management system which sends advisory messages to a user. The primary purpose of GMM is to reduce the risk of overloading a user with information when multiple failures occur, and to assist the developer in devising an explanation facility.

The emphasis of our work is to develop practical tools and techniques, including identification of appropriate software tools to support research, application, and tool building activities, while determining the feasibility of a given approach.

A GENERAL-PURPOSE DEVELOPMENT ENVIRONMENT FOR INTELLIGENT COMPUTER-AIDED TRAINING SYSTEMS

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Abstract

Space Station training will be a major task, requiring the creation of large numbers of simulation-based training systems for crew, flight controllers, and ground-based support personnel. Given the long duration of Space Station missions and the large number of activities supported by the Space Station, the extension of space shuttle training methods to Space Station training may prove to be impractical. The application of artificial intelligence technology to simulation training can provide the ability to deliver individualized training to large numbers of personnel in a distributed workstation environment. The principal objective of this project is the creation of a software development environment which can be used to build intelligent training systems for procedural tasks associated with the operation of the Space Station. Current NASA Johnson Space Center projects and joint projects with other NASA operational centers will result in specific training systems for existing space shuttle crew, ground support personnel, and flight controller tasks. Concurrently with the creation of these systems, a general-purpose development environment for intelligent computer-aided training systems will be built. Such an environment would permit the rapid production, delivery, and evolution of training systems for Space Station crew, flight controllers, and other support personnel. The widespread use of such systems will serve to preserve task and training expertise, support the training of many personnel in a distributed manner, and ensure the uniformity and verifiability of training experiences. As a result, significant reductions in training costs can be realized while safety and the probability of mission success can be enhanced.

N94- 72204

PLATFORM MANAGEMENT SYSTEM (PMS) EVOLUTION

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Abstract

In fiscal year 1988 a study was begun to define the platform management system (PMS) functions required for the mature platform operations era. The objectives of the task include:

1. defining how to increase the operational productivity of the platform by providing enhanced capability for responding to changing events,

2. influencing the initial PMS design by identifying required "hooks and scars", and

3. evaluating potential automation techniques that are appropriate given predicted onboard computing resources.

Initial platform operations scenarios were defined. The focus was on PMS-related functions where operations enhancements are likely to occur. Operations productivity was defined in terms of scientific productivity of the platform as well as the level of automation of the ground system. The Platform Operations Productivity Enhancement Report was completed earlier this year documenting system enhancements to increase science productivity and ground system automation.

Using the baseline PMS defined in the PMS Definition Document as a starting point, the resulting PMS-specific enhancements were molded into a sequence of progressively more sophisticated operations management capabilities. This sequence of upgrades to the PMS has been documented in a PMS Evolution Plan. The plan includes enhancements in the areas of resource scheduling, resource modeling, system and payload anomaly management, and transaction sequence interpretation. A plan for migration of functions from the ground portion of the PMS to the flight portion is also included. The impacts of this plan on the platform are now being documented to ensure that the required "hooks and scars" are included in the baseline system.

Future plans include a prototype of some of the PMS enhancements to address the feasibility of and techniques for implementing these enhancements in the onboard computing environment.

AUTOMATED PLATFORM MANAGEMENT SYSTEM SCHEDULING

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Abstract

The Platform Management System (PMS) has been established to coordinate the operation of platform systems and payloads. Since platforms are to be out of contact with the ground more than the manned base, PMS functions are required to be more autonomous than those of the manned base. Automated replanning and rescheduling will be required to effectively and efficiently meet mission goals.

In a FY88 study, we developed a phased approach to automated PMS scheduling based upon use of the same scheduling engine in both ground and space components. In the past year, we implemented a baseline, first phase, PMS scheduler prototype. Presently we are integrating this scheduler into two NASA Goddard Space Flight Center testbeds, as the ground scheduler in the Scheduling Concepts, Architectures, and Networks Testbed and as the onboard scheduler in the PMS Testbed. We will investigate rescheduling issues, evaluate operational performance and enhance the prototype to demonstrate our evolutionary approach to automated PMS scheduling.

CONCEPTS IN DISTRIBUTED PLANNING, SCHEDULING AND CONTROL

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Larry Hull
NASA Goddard Space Flight Center

Abstract

To support instrument and experiment operations effectively in the Space Station era, planning, scheduling, and control must allow for:

1. interactive real-time remote operations;
2. responsive scheduling and rescheduling;
3. support of the full range of distributed science, application and commercial users;
4. interaction and cooperation among distributed users; and
5. efficient use of often limited onboard, communications, and ground-based resources.

We suggest conceptual and managerial approaches that address these needs.

Specifically, we describe approaches to distributed planning, scheduling and control functions that are based on resources and on a distributed knowledge hierarchy. We describe the scheduling functions as the component of the integrated space-ground Operations Management System.

We include the integration of the planning and scheduling functions with the real-time operations control system, and we discuss automated scheduling assistants.

These suggested approaches, taken from the users' point-of-view, have resulted in two prototype systems: Operations and Science Instrument Support package and Science User Resource Planning and Scheduling System.

OPERATIONS ANALYSIS FOR EVOLUTION STATION CONCEPTS

Karen D. Brender
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Abstract

This will be a brief overview of the analyses that have been conducted to study the operations of the evolution reference configurations and the Lunar/Mars Initiative Space Station configuration. In addition, plans for the next phases of operations analysis will be discussed. The presentation will also include a discussion of the products required from the Operations Evolution session.

N94- 72207

VEHICLE PROCESSING OPERATIONS DATABASE

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530- 82

Abstract

The Vehicle Processing Operations Data base (VPOD) has been designed and constructed to enable the collection and preliminary analysis of data relative to the processing of planetary exploration vehicles in low Earth orbit. VPOD has the capability to hierarchically store the events, assemblies, and equipment data needed for performing vehicle processing analysis, to whatever level of detail available. This permits some analysis to be performed even during the very early phases of vehicle and mission design. As more data about the events, assemblies, or equipment become available, the analysis can then be refined using the increased level of detail. VPOD output is based on a mission defined by selecting from the VPOD Events data base the events that are required to perform the desired tasks. The outputs available include total crew time, crew skill requirements, equipment needed, and assemblies worked per event, to any available level of detail.

The VPOD design is structured to interface with an operations simulation capability, which is currently in the requirements definition phase. The simulator will use information from the VPOD to perform operations analysis for missions being conducted in low Earth orbit. VPOD information, along with information from the science missions operations data base and a Space Station configuration data base, will be used by the simulator to provide a capability to study total system operations and resource requirements.

N94-72208

ON-ORBIT ASSEMBLY/SERVICING TASK DEFINITION STUDY

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Abstract

The OEXP vehicles being envisioned to carry out the Presidential space goals of a lunar outpost and human exploration of Mars will require on-orbit assembly, refurbishment, checkout, and launch. The On-orbit Assembly/Servicing Task Definition Study applies the space vehicle processing experience and procedures archives resident at NASA's Kennedy Space Center (KSC) to determine the tasks, flows, and resources/facilities necessary to process the OEXP vehicles at Space Station Freedom (SSF). This data base is examined to find the closest analogies to OEXP vehicle components and assembly/refurbishment tasks. Transition tables are generated to provide traceability from KSC hardware processing experience to analogous on-orbit processing of the OEXP vehicles. Iterations in which the task flows are broken down into realistic extravehicular activity (EVA) primitive subtasks and times, and to apply automation and robotic technology to reduce crew risks and minimize EVA time, will enhance the value and accuracy of the predicted flows. These processing scenarios and the resulting resource/facility requirements are used to determine impacts to SSF, resulting in change requests to SSF requirements for provision of "hooks and scars" to evolve the assembly complete Space Station into a transportation node. Study results to date include assembly analysis of the Martin Marietta Phobos Gateway Vehicle, refurbishment analysis of the Martin Marietta Lunar Evolution Piloted and Cargo Vehicles, and assembly analysis of the Boeing Mars Evolution Vehicle. The results of this study will be accumulated into the vehicle processing operations data base for subsequent modeling, life cycle cost, vehicle growth, and SSF impact analysis.

ADVANCED ROBOTICS FOR IN-SPACE VEHICLE PROCESSING

Jeffrey H. Smith
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Abstract

An analysis of spaceborne vehicle processing is described. Generic crew-extravehicular activity tasks are presented for a specific vehicle, the orbital maneuvering vehicle (OMV), with general implications to other on-orbit vehicles. The OMV is examined with respect to both servicing and maintenance. Crew-EVA activities are presented by task and mapped to a common set of generic crew-EVA primitives to identify high-demand areas for robot services. Similarly, a set of robot primitives is presented that can be used to model robot actions for alternative robot reference configurations. The robot primitives are tied to technologies and used for composing robot operations for an automated refueling scenario. Robotics technology issues and design accommodation guidelines (hooks and scars) for Space Station Freedom are described.

ADVANCED AUTOMATION FOR IN-SPACE VEHICLE PROCESSING

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NASA Kennedy Space Center

Abstract

The primary objective of this 3-year planned study is to assure that the fully evolved Space Station Freedom (SSF) can support automated processing of exploratory mission vehicles. Current study assessments show that required extravehicular activity (EVA) and to some extent intravehicular activity (IVA) manpower requirements for required processing tasks far exceeds the available manpower. Furthermore, many processing tasks are either hazardous operations or they exceed EVA capability. Thus, automation is essential for SSF transportation node functionality. Here, advanced automation represents the replacement of human performed tasks beyond the planned baseline automated tasks. Both physical tasks such as manipulation, assembly and actuation, and cognitive tasks such as visual inspection, monitoring and diagnosis, and task planning are considered. During this first year of activity both the Phobos/Gateway Mars Expedition and Lunar Evolution missions proposed by the Office of Exploration have been evaluated. A methodology for choosing optimal tasks to be automated has been developed. Processing tasks for both missions have been ranked on the basis of automation potential. The underlying concept in evaluating and describing processing tasks has been the use of a common set of "Primitive" task descriptions. Primitive or standard tasks have been developed both for manual or Crew processing and automated machine processing.

SPACE VEHICLE DEPLOYMENT FROM SPACE STATION

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Abstract

When launching a spacecraft from Earth parking orbit to deep space, it is highly desirable to have the hyperbolic excess velocity vector (v-infinity) contained in the parking orbit plane. Ground launches can force the parking orbit plane to contain the v-infinity vector by using launch azimuth and lift-off time as independent variables. When launching from the Space Station, a new set of variables comes into play. The Space Station orbit is of fixed inclination but precessing due to the Earth's oblateness. Its plane will seldom (and may never) contain the desired v-infinity vector. Consequently, the departure strategy will usually require multiple burns and include a plane change. Also, the concept of "launch window" will be somewhat different from Earth surface launches. An analysis of the deployment of interplanetary spacecraft from the Space Station is described, with emphasis on the effect of the trajectory characteristics on station operations. Several planetary mission types are analyzed, including manned Mars missions and unmanned high declination departures. The constraint of Space Station orbit nodal position is quantified and the operational implications for Space Station reboost strategy are examined.

N94-72212

GRAPHICAL ANALYSIS OF MARS VEHICLE ASSEMBLY

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Abstract

An analysis was performed to support the production of a computer graphics videotape of the assembly of an interplanetary vehicle at a man-tended transportation node, co-orbiting with Space Station Freedom. Using data provided by the Transportation Node Integration Agent of the Lunar-Mars Exploration Office, a workable design of the transportation node was developed. Kinematic manipulator simulation tools were used to perform the operations necessary to complete the assembly task. Results of this analysis are documented in the aforementioned video.

DATA MANAGEMENT SYSTEM ADVANCED DEVELOPMENT

Katherine Douglas and Terry Humphries
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Abstract

The Data Management System (DMS) Advanced Development task provides for the development of concepts, new tools, DMS services, and for the testing of the Space Station DMS hardware and software. It also provides for the development of techniques capable of determining the effects of system changes/enhancements, additions of new technology, and/or hardware and software growth on system performance.

This paper will address the built-in characteristics which will support network monitoring requirements in the design of the evolving DMS network implementation, functional and performance requirements for a real-time, multiprogramming, multiprocessor operating system, and the possible use of advanced development techniques such as expert systems and artificial intelligence tools in the DMS design.

N94-72214

OPERATIONS MANAGEMENT SYSTEM ADVANCED AUTOMATION: FAULT DETECTION ISOLATION AND RECOVERY PROTOTYPING

Matt Hanson
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Abstract

The purpose of this project is to address the global fault detection, isolation and recovery (FDIR) requirements for Operation's Management System (OMS) automation within the Space Station Freedom program. This shall be accomplished by developing a selected FDIR prototype for the Space Station Freedom distributed processing systems. The prototype shall be based on advanced automation methodologies in addition to traditional software methods to meet the requirements for automation. A secondary objective is to expand the scope of the prototyping to encompass multiple aspects of station-wide fault management (SWFM) as discussed in OMS requirements documentation.

N94-72215

OMS EVENT EVALUATOR AND SCHEDULER

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Abstract

An Operations Management System (OMS) is being designed for Space Station Freedom to improve productivity, reliability, and safety while reducing operations and maintenance costs. Central to the concept is a short-term plan containing mixes of man-readable and machine-executable procedures used in an environment of distributed processing and execution. An OMS event evaluator to check upcoming short-term-plan events for validity of execution is under development. The first version checks time and resource constraints against operational conditions for current or expected stations. In work are the handling of environmental and other operational constraints, as well as detailed modeling of resources and station operational states. The Ada program also has the ability to reschedule all or part of the events.

N94-72216

AUTOMATED SOFTWARE DEVELOPMENT WORKSTATION (ASDW)

Ernie Fridge
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Abstract

Software development is a serious bottleneck in the construction of complex automated systems. An increase of the reuse of software designs and components has been viewed as a way to relieve this bottleneck. One approach to achieving software reusability is through the development and use of software parts composition systems. A software parts composition system is a software development environment comprised of a parts description language for modeling parts and their interfaces, a catalog of existing parts, a composition editor that aids a user in the specification of a new application from existing parts, and a code generator that takes a specification and generates an implementation of a new application in a target language. The Automated Software Development Workstation (ASDW) is an expert system shell that provides the capabilities required to develop and manipulate these software parts composition systems. The ASDW is now in Beta testing at the Johnson Space Center. Future work centers on responding to user feedback for capability and usability enhancement, expanding the scope of the software lifecycle that is covered, and in providing solutions to handling very large libraries of reusable components.

N94-72217

TMIS - DESIGN KNOWLEDGE CAPTURE

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Abstract

The Boeing Advanced Technology Center is conducting research towards the goal of building a corporate memory facility that will provide techniques for capturing and using decision history and rationale throughout the lifecycle of a major NASA program. Currently, much of the information regarding decision alternatives and trade-offs made in the course of a major program development effort is not represented or retained in a way that permits computer-based reasoning over the lifecycle of the program. The loss of this information results in problems in tracing design alternatives to requirements, in assessing the impact of change in requirements, in assessing the impact of change in requirements, and in configuration management.

To address these problems, we are studying the problem of building an intelligent, active corporate memory facility which would provide for the capture of the requirements and standards of a program, analyze the design alternatives and trade-offs made over the program's lifetime, and examine relationships between requirements and design trade-offs.

EVOLUTION PATHS FOR ADVANCED AUTOMATION

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Abstract

As Space Station Freedom (SSF) evolves, increased automation and autonomy will be required to meet Space Station Freedom Program (SSFP) objectives. As a precursor to the use of advanced automation within the SSFP, especially if it is to be used on SSF (e.g., to automate the operation of the flight systems), the underlying technologies will need to be elevated to a high level of readiness to ensure safe and effective operations. Ground facilities supporting the development of these flight systems--from research and development laboratories through formal hardware and software development environments--will be responsible for achieving these levels of technology readiness. These facilities will need to evolve to support the general evolution of the SSFP. This evolution will include support for increasing the use of advanced automation. The SSF Advanced Development Program has funded a study to define evolution paths for advanced automation within the SSFP's ground-based facilities which will enable, promote, and accelerate the appropriate use of advanced automation on-board SSF. The current capability of the test beds and facilities, such as the Software Support Environment, with regard to advanced automation, has been assessed and their desired evolutionary capabilities have been defined. Plans and guidelines for achieving this necessary capability have been constructed. The approach taken has combined indepth interviews of test bed personnel at all SSF Work Package centers with awareness of relevant state-of-the-art technology and technology insertion methodologies. Key recommendations from the study include advocating a NASA-wide task force for advanced automation, and the creation of software prototype transition environments to facilitate the incorporation of advanced automation in the SSFP.

ART/ADA AND CLIPS/ADA

Chris Culbert
NASA Johnson Space Center

Abstract

Although they have reached a point of commercial viability, expert systems were originally developed in artificial intelligence (AI) research environments. Many of the available tools still work best in such environments. These environments typically utilize special hardware such as LISP machines and relatively unfamiliar languages such as LISP or Prolog. Space Station applications will require deep integration of expert system technology with applications developed in conventional languages, specifically Ada. The ability to apply automation to Space Station functions could be greatly enhanced by widespread availability of state-of-the-art expert system tools based on Ada. Although there have been some efforts to examine the use of Ada for AI applications, there are few, if any, existing products which provide state-of-the-art AI capabilities in an Ada tool.

The goal of the ART/Ada Design Project is to conduct research into the implementation in Ada of state-of-the-art hybrid expert systems building tools (ESBTs). This project takes the following approach: using the existing design of the ART-IM ESBT as a starting point, analyze the impact of the Ada language and Ada development methodologies on that design, redesign the system in Ada, and analyze its performance. The research project will attempt to achieve a comprehensive understanding of the potential for embedding expert systems in Ada systems for eventual application in future Space Station Freedom projects. During Phase I of the project, initial requirements analysis, design and implementation of the kernel subset of ART-IM functionality was completed. During Phase II, effort has been focused on the implementation and performance analysis of several versions with increasing functionality.

Since production quality ART/Ada tools will not be available for a considerable time, an additional subtask of this project will be the completion of an Ada version of the CLIPS expert system shell developed by NASA. This tool will provide full syntactic compatibility with any eventual products of the ART/Ada design while allowing SSFP developers early access to this technology.

N94-72220

KNOWLEDGE-BASED SYSTEM VERIFICATION AND VALIDATION

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Abstract

The objective of this task is to develop and evaluate a methodology for verification and validation (V&V) of knowledge-based systems (KBS) for space station applications with high reliability requirements.

The approach consists of three interrelated tasks. The first task is to evaluate the effectiveness of various validation methods for space station applications. The second task is to recommend requirements for KBS V&V for Space Station Freedom (SSF). The third task is to recommend modifications to the SSF to support the development of KBS using effective software engineering and validation techniques.

To accomplish the first task, three complementary techniques will be valuated:

Sensitivity Analysis (Worchester Polytechnic Institute)
Formal Verification of Safety Properties (SRI International)
Consistency and Completeness Checking (Lockheed AI Center)

During FY89 and FY90, each contractor will independently demonstrate the use of his technique on the fault detection, isolation, and reconfiguration (FDIR) KBS or the manned maneuvering unit (MMU), a rule-based system implemented in LISP. During FY91, the application of each of the techniques to other knowledge representations and KBS architectures will be addressed.

After evaluation of the results of the first task and examination of Space Station Freedom V&V requirements for conventional software, a comprehensive KBS V&V methodology will be developed and documented.

Development of highly reliable KBSs cannot be accomplished without effective software engineering methods. Using the results of current in-house research to develop and assess software engineering methods for KBSs as well as assessment of techniques being developed elsewhere, an effective software engineering methodology for space station KBSs will be developed, and modification of the SSF to support these tools and methods will be addressed.

INTELLIGENT SYSTEMS ENGINEERING METHODOLOGY

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Abstract

An added challenge for the designers of large scale systems such as Space Station Freedom is the appropriate incorporation of intelligent system technology (artificial intelligence, expert systems, knowledge-based systems, etc.) into their requirements and design. This presentation will describe a view of systems engineering which successfully addresses several aspects of this complex problem: design of large scale systems, design with requirements that are so complex they only completely unfold during the development of a baseline system and even then continue to evolve throughout the system's life cycle, design that involves the incorporation of new technologies, and design and development that takes place with many players in a distributed manner yet can be easily integrated to meet a single view of the requirements.

The first generation of this methodology was developed and evolved jointly by ISX and the Lockheed Aeronautical Systems Company over the past five years on the Defense Advanced Research Projects Agency/Air Force Pilot's Associate Program, one of the largest, most complex, and most successful intelligent systems constructed to date. As the methodology has evolved it has also been applied successfully to a number of other projects. Some of the lessons learned from this experience may be applicable to Freedom.

N94-72222

SOFTWARE SUPPORT ENVIRONMENT DESIGN KNOWLEDGE CAPTURE

Tom Dollman
NASA Marshall Space Flight Center

Abstract

The objective of this task is to assess the potential for using the software support environment (SSE) workstations and associated software for design knowledge capture (DKC) tasks. This assessment will include the identification of required capabilities for DKC and hardware/software modifications needed to support DKC. Several approaches to achieving this objective are discussed and interim results are provided:

1. research into the problem of knowledge engineering in a traditional computer-aided software engineering (CASE) environment, like the SSE;

2. research into the problem of applying SSE CASE tools to develop knowledge based systems; and

3. direct utilization of SSE workstations to support a DKC activity.

N94- 72223

ADVANCED DATA MANAGEMENT SYSTEM ARCHITECTURES TESTBED

Terry Grant
Intelligent Systems Technology Branch
NASA Ames Research Center

Abstract

The objective of the Architecture and Tools Testbed is to provide a working, experimental focus to the evolving automation applications for the Space Station Freedom data management system. Emphasis is on defining and refining real-world applications... including the validation of user needs, understanding system requirements and capabilities, as well as extending capabilities.

The approach is to provide an open, distributed system of high performance workstations representing both the standard data processors and networks, and advanced RISC-based processors and multiprocessor systems. The system provides a base from which to develop and evaluate new performance and risk management concepts, and for sharing the results. Participants are given a common view of requirements and capability via: remote login to the testbed; standard, natural user interfaces to simulations and emulations; special attention to users manuals for all software tools; and E-mail communication. The testbed elements which instantiate the approach are briefly described including the workstations, the software simulation and monitoring tools, and performance and fault tolerance experiments.

N94-72224

SPACEBORNE AUTONOMOUS MULTIPROCESSOR SYSTEMS

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NASA Ames Research Center

Abstract

The goal of this task is to provide technology for the specification and integration of advanced processors into the Space Station Freedom data management system environment through computer performance measurement tools, simulators, and an extended testbed facility. The approach focuses on five categories:

1. user requirements: determine the suitability of existing computer technologies and systems for real-time requirements of NASA missions;

2. system performance analysis: characterize the effects of languages, architectures, and commercially available hardware on real-time benchmarks;

3. system architecture: expand NASA's capability to solve problems with integrated numeric and symbolic requirements using advanced multiprocessor architectures;

4. parallel Ada technology: extend Ada software technology to utilize parallel architectures more efficiently; and

5. testbed: extend in-house testbed to support system performance and system analysis studies.

N94-72225

THE ISES: A NON-INTRUSIVE MEDIUM FOR IN-SPACE EXPERIMENTS IN ON-BOARD INFORMATION EXTRACTION

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Abstract

The Information Sciences Experiment System (ISES) represents a new approach in applying advanced systems technology and techniques to on-board information extraction in the space environment. Basically, what is proposed is a "black box" attached to the spacecraft data bus or local area network. To the spacecraft the "black box" appears to be just another payload requiring power, heat rejection, interfaces, adding weight, and requiring time on the data management and communication system. In reality, the "black box" is a programmable computational resource which eavesdrops on the data network, taking and producing selectable, real-time science data back on the network.

This paper will present a brief overview of the ISES Concept and will discuss issues related to applying the ISES to the polar platform and Space Station Freedom. Critical to the operation of ISES is the viability of payload-like interface to the spacecraft data bus or local area network. Study results that address this question will be reviewed vis-a-vis the solar platform and the core space station. Also, initial results of processing science and other requirements for onboard, real-time information extraction will be presented with particular emphasis on the polar platform. Opportunities for a broader range of applications on the core space station will also be discussed.

AUTONOMOUS CONTROL

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Abstract

Kennedy Space Center has been developing the Knowledge-Based Autonomous Test Engineer (KATE), a tool for performing automated monitoring, diagnosis, and control of electromechanical devices. KATE employs artificial intelligence computing techniques to perform these functions. The KATE system consists of a generic shell and a knowledge base. The KATE shell is the portion of the system which performs the monitoring, diagnosis, and control functions. It is generic in the sense that it is application independent. This means that the monitoring activity, for instance, will be performed with the same algorithms regardless of the particular physical device being used. The knowledge base is the portion of the system which contains specific functional and behavorial information about the physical device KATE is working with.

Work is nearing completion on a project at KSC to interface a Texas Instruments Explorer running a LISP version of KATE with a Generic Checkout System (GCS) test-bed to control a physical simulation of a shuttle tanking system (humorously called the Red Wagon because of its color and mobility).

The Autonomous Control System (ACS) project supplements and extends the KATE/GCS project by adding three other major activities. The activities include: porting KATE from the Texas Instruments Explorer machine to an Intel 80386-based UNIX workstation in the LISP language, rewriting KATE as necessary to run on the same 80366 workstation but in the Ada language, and investigating software and techniques to translate ANSI Standard Common LISP to Mil Standard Ada.

Primary goals of this task are (1) establish the advantages of using expert systems to provide intelligent autonomous software for Space Station Freedom applications, (2) determine the feasibility of using Ada as the run-time environment for model-based expert systems, (3) provide insight into the advantages and disadvantages of using LISP or Ada in the run-time environment for expert systems, and (4) compare the performance of the 80386 processor to a symbolic processor as a delivery vehicle for expert systems.

N94- 72227

THE JET PROPULSION LABORATORY SHARED CONTROL ARCHITECTURE AND IMPLEMENTATION

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Abstract

A hardware and software environment for shared control of telerobot task execution has been implemented. Modes of task execution range from fully teleoperated to fully autonomous as well as shared where hand controller inputs from the human operator are mixed with autonomous system inputs in real time.

The objective of the shared control environment is to aid the telerobot operator during task execution by merging real-time operator control from hand controllers with autonomous control to simplify task execution for the operator. The operator is the principal command source and can assign as much autonomy for a task as desired.

The shared control hardware environment consists of two PUMA 560 robots, two 6-axis force reflecting hand controllers, Universal Motor Controllers for each of the robots and hand controllers, a SUN4 computer, and VME chassis containing 68020 processors and input/output boards. The operator interface for shared control, the User Macro Interface (UMI), is a menu driven interface to design a task and assign the levels of teleoperated and autonomous control. The operator also sets up the system monitor which checks safety limits during task execution. Cartesian-space degrees of freedom for teleoperated and/or autonomous control inputs are selected within UMI as well as the weightings for the teleoperation and autonomous inputs. These are then used during task execution to determine the mix of teleoperation and autonomous inputs.

Some of the autonomous control primitives available to the user are Joint-Guarded-Move, Cartesian-Guarded-Move, Move-To-Touch, Pin-Insertion/Removal, Door/Crank-Turn, Bolt-Turn, and Slide. The operator can execute a task using pure teleoperation or mix control execution from the autonomous primitives with teleoperated inputs.

Presently the shared control environment supports single arm task execution. Work is presently underway to provide the shared control environment for dual arm control. Teleoperation during shared control is only Cartesian space control and no force-reflection is provided. Force-reflecting teleoperation and joint space operator inputs are planned extensions to the environment.

N94-72228

JET PROPULSION LABORATORY/KENNEDY SPACE CENTER TELEROBOTIC INSPECTION AND MANIPULATION DEMONSTRATION

Brian Wilcox
NASA Jet Propulsion Laboratory

Leon Davis
NASA Kennedy Space Center

Abstract

The goal of this effort is to demonstrate telerobotic inspection and manipulation of space shuttle payloads in the presence of substantial communications time delays between the operator station and the robotic work space. Processing of space shuttle payloads provides a variety of tasks which are typical of both space shuttle ground operations and Space Station in-flight operations, and communications time delays are inevitable in space operations where the operator station will be light-seconds away from the telerobot. With this demonstration we hope to show the efficacy and safety of robotic technology for ground and space operations.

Our approach is to develop an experimental telerobotic system with the remote sensing, actuation and reflex portions located at Kennedy Space Center (KSC) in Florida, while the operator control station will be located at Jet Propulsion Laboratory (JPL) in California. The JPL portion of the system includes a high-level operator interface, intelligent spatial planning and machine vision, while the KSC portion includes the robot arm, end effectors, cameras and proximity sensors, and the necessary control and communications computers and software. The communications between JPL and KSC are over a limited-bandwidth network channel (19200 baud) with unpredictable and unrepeatable time delays.

In FY89 we integrated a basic version of the robotic, communications and computer hardware, and developed the software to perform an operator-supervised inspection of a PAM-D satellite upper stage rocket motor and its shuttle support cradle. The demonstration, though severely limited by the bulk of the available computer arm, showed the potential of telerobotics for inspection tasks.

In the future, we plan to develop additional capabilities which will allow manipulation tasks to be performed, including removal of dust covers and lens caps, insertion of connectors and batteries, and installation of payload objects.

N94-72229

ROBOTIC ASSEMBLY OF LARGE SPACE STRUCTURES

Ralph W. Will and Marvin D. Rhodes
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Abstract

The Automated Structures Assembly Laboratory (ASAL) has been developed at Langley Research Center for the purpose of identifying the problems associated with assembling large space structures using robotic manipulators, investigating systems and techniques applicable to such assembly tasks, and developing methodology for an in-space construction facility. The ASAL facility and its robotic manipulator system is described and a discussion of the initial series of assembly operations are included. The status of the system software development is summarized and an outline for follow-on testing and expanded capability is given.

OMIT

SPACE STATION INTRAVEHICULAR ACTIVITY (IVA) PAYLOAD TENDING ROBOT

E.C. Smith
NASA Marshall Space Flight Center

Abstract

The development of a ground-based robotic system to demonstrate intravehicular activity payload experiment tending is near completion. Results from system testing will assist in the ongoing planning for a flight demonstration system. Status and plans to date will be presented.

N94-72230

VIRTUAL WORKSTATIONS AND TELEPRESENCE INTERFACES: DESIGN ACCOMMODATIONS AND PROTOTYPES FOR SPACE STATION FREEDOM EVOLUTION

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Abstract

An advanced human-system interface is being developed for evolutionary Space Station Freedom as part of the NASA Office of Space Station (OSS) Advanced Development Program. The human-system interface is based on body-pointed display and control devices. The project will identify and document the design accommodations ("hooks and scars") required to support virtual workstations and telepresence interfaces, and prototype interface systems will be built, evaluated, and refined. The project is a joint enterprise of Marquette University, Astronautics Corporation of America (ACA), and NASA's Ames Research Center (ARC). The project team is working with NASA's Johnson Space Center (JSC) and McDonnell Douglas Astronautics Company (the Work Package 2 contractor) to ensure that the project is consistent with space station user requirements and program constraints. Documentation describing design accommodations and tradeoffs will be provided to OSS, JSC, and McDonnell Douglas, and prototype interface devices will be delivered to ARC and JSC. ACA intends to commercialize derivatives of the interface for use with computer systems developed for scientific visualization and system simulation.

TEJAS

Michael Drews
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Abstract

The Telerobotics/EVA Joint Analysis System (TEJAS) is a hypermedia information system that provides a clear, consistent, repeatable, interactive, and exchangeable multilevel mechanism for telerobotics technology development planning, based on a realistic understanding of

1. Task description, assumptions, and open issues
2. Specific task primitives (derived from generic primitives)
3. Technologies required to perform on-orbit telerobotics
4. Planned telerobotics systems' use of those technologies
5. Forecast for each technology in terms of time and money

TEJAS was created in HyperCard on a Macintosh II personal workstation, with HyperTalk scripts providing action and relational capability. Version 1.0, consisting of more than a dozen interrelated files, will be released in January 1990.

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